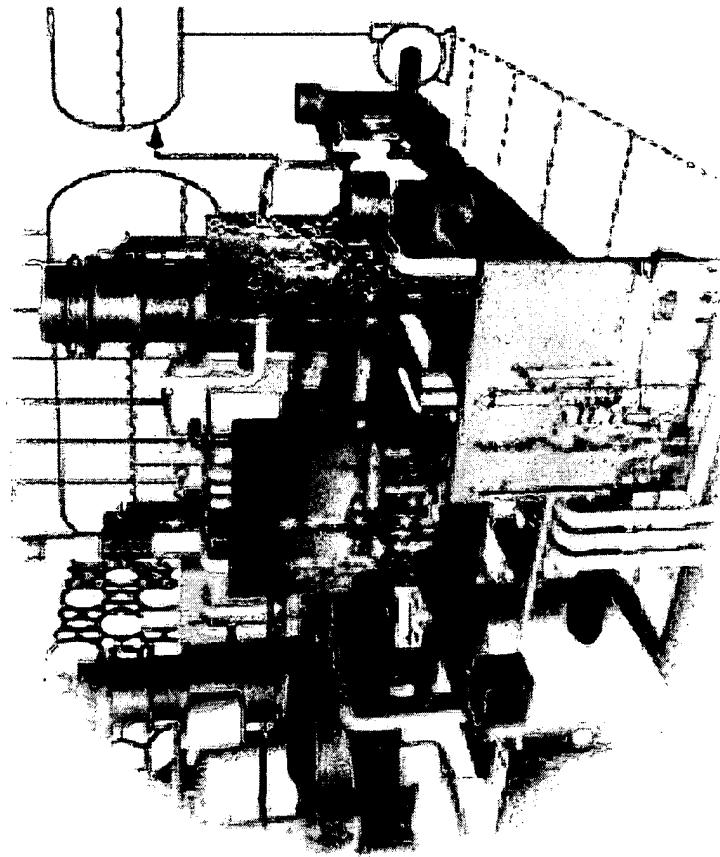


Delivering Value for Resid and Heavy Feed

**1st Russia & CIS
Bottom of the Barrel
Technology Conference
Moscow
April 19, 2005**

**Dr. Paul Kamienski
Dr. Anna Gorshteyn
Mr. Glen Phillips
Mr. Andrew Woerner**



ExxonMobil
Research and Engineering

Outline

- Installed Capacity & Technology Selection
- FLUID COKING™ and FLEXICOKING™
- Economic Comparison of Options

Growing Interest in Resid Conversion - Why Now?

Driver

**Rising
Crude Cost**



Refiners' Response

- Produce More Clean Products per Crude Barrel
- Process Lower Cost Heavier Crudes
- Increase Production of Heavy Crude Resources

**Declining
Fuel Oil Demand**



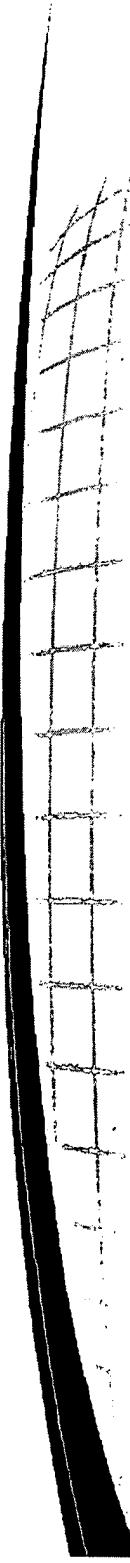
- Implement High Return Conversion Projects
- Move to Bottomless / Fuel Oil Free Refinery

**Higher Natural
Gas Price**



- Optimize Refinery Fuel Usage
- Employ Technologies that use Lower Cost Fuels
- Find Lower Cost Energy Sources for Oil Recovery

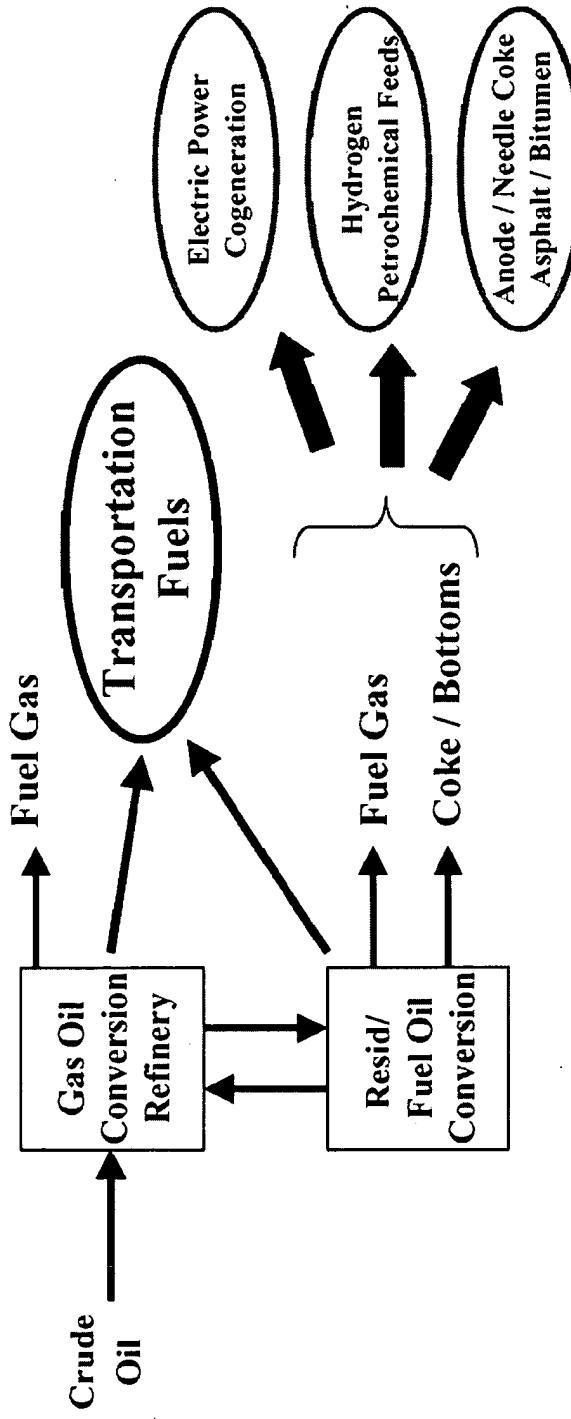
Refiners Today Consider Broader / More Flexible Approaches



Production of Clean Transportation Fuels is Important.....

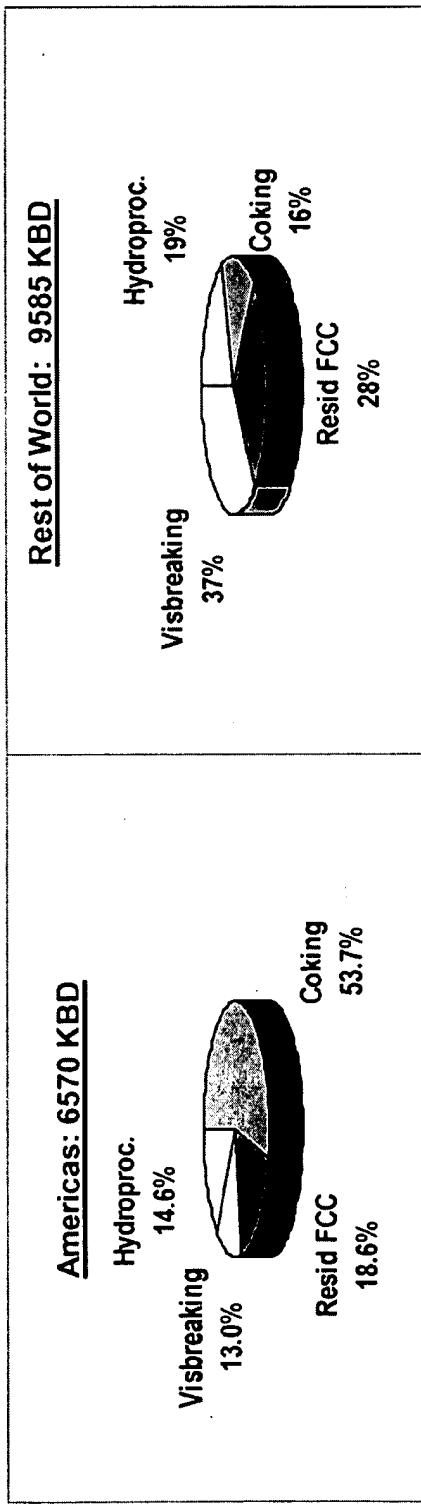
....But Also Want the Flexibility to Capture New Opportunities

- Process Lower Cost / Poorer Quality Crudes / Resids
- New Markets
- Staged Investments



Resid Processing Capacity: Type and Trend

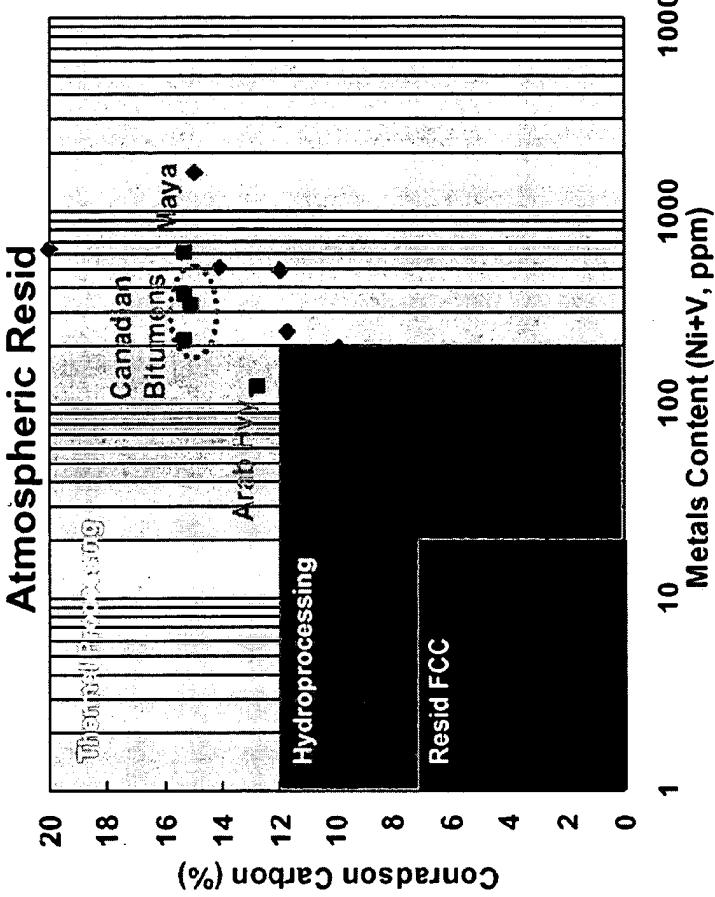
- Americas have >40% of World Wide Installed Resid Conversion Capacity
 - Coking the Predominant Processing Choice
 - Visbreaking Widely Used in Rest of World



- Hydroprocessing in Areas with Fuel Oil Outlets and Suitable Crudes
 - Capacity increased ~200 kbd from 1999 - 2003
 - Coking Capacity increase ~1000 kbd from 1999 - 2003
 - Approximately 25% in Upstream Projects (e.g. Canada , Venezuela)
 - ExxonMobil operates ~860 KBD of Resid Capacity; ~60% is Coking

Resid Quality Drives Refinery Conversion Options

- Resid FCC OK with Good Resids
 - Metals deactivation and coke burning capability are constraints
- Hydroconversion Can Be Used with Moderate Quality Resids
 - Moving bed or onstream replacement used to mitigate catalyst deactivation
 - Limited to moderate conversion by product incompatibility
 - Bottoms disposal an issue
- Thermal Conversion Best with Poor Feeds
 - Reject Carbon and Metals to Coke
 - Delayed Coking
 - FLUID COKING, FLEXICOKING



FLUID COKING / FLEXICOKING / Delayed Coking Comparison

FLUID COKING / FLEXICOKING

- Liquid Product Yields Slightly Higher Than in Delayed Coking

Continuous Process

- Steady state operations
- Staffing requirements low

Handles Virtually Any Pumpable Hydrocarbon Feed

Coke Has Multiple Roles

- Heat transfer medium
- Low value coke supplies process heat

Utilities

- Little or no fuel gas use
- High net steam generation

Environmental

- FLK offgas scrubbed to meet sulfur emissions limit
- FXK coke gas desulfurized to make low sulfur clean fuel for refinery use

Delayed Coking

Liquid Product Quality Slightly Better Than Fluid Bed Coking

Cyclic Process

- Short drum cycles (12-18 hours)
- Temperature cycles / Drum stressing
- Staffing requirements high

High CCR Feeds Can Coke Furnace

- More frequent spalling/decoking
- Feed “dilution”, derating throughput

- **Coke Is Only a Reaction Product**
- Produce more coke than FLUID COKING

Utilities

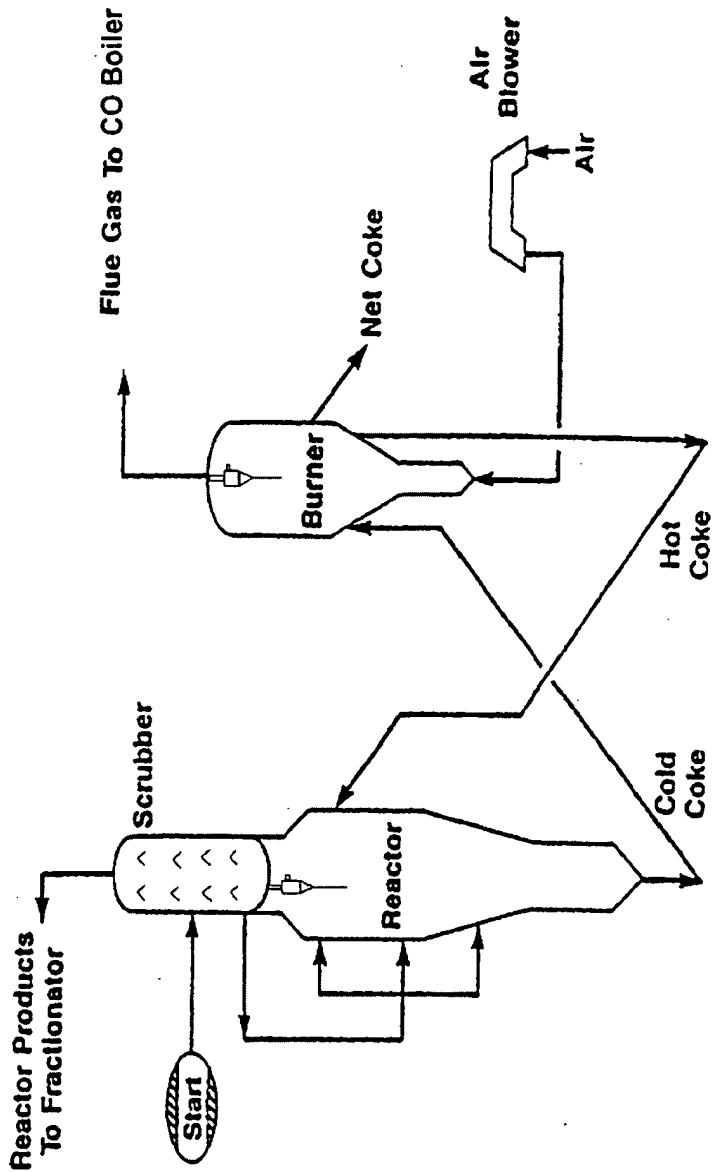
- Furnaces use large amount of fuel gas
- Almost zero net steam generation

Environmental

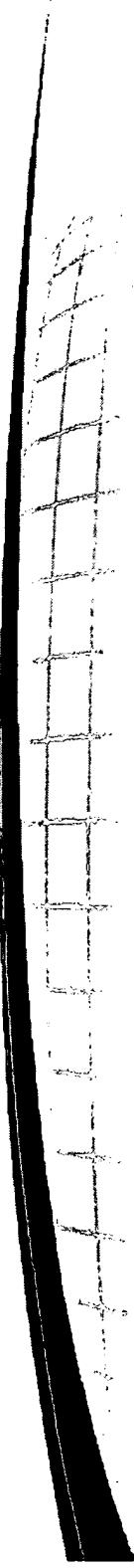
- Open coke piles becoming problematic
- Require low sulfur fuel gas to meet sulfur emission limits

FLUID COKING Process

- Continuous Fluid Bed Processes
- Developed Based on ExxonMobil Fluid Catalytic Cracking technology



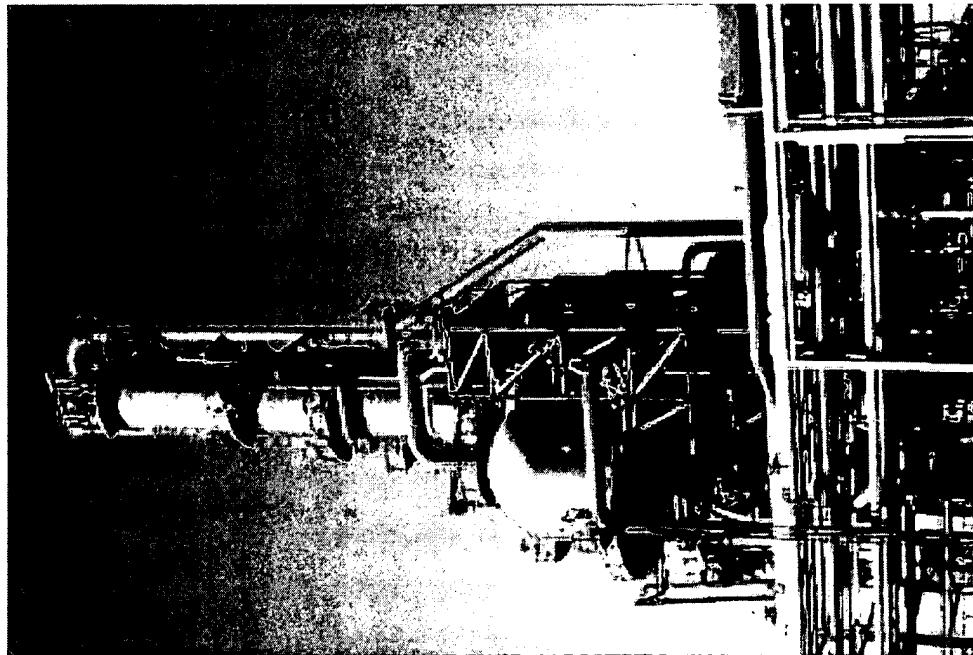
Operating Principles of FLUID COKING



- Hot Resid Sprayed into Fluidized Coke Bed
 - Coking reactions occur in thin film on outside of coke particles
 - Small particles provide surface area for reaction
 - Coke bed fluidized by product vapors & steam at bottom of reactor
- Product Vapors Flow Overhead Through Cyclones to Scrubber
 - Cyclones remove bulk of coke particles
 - Scrubber condenses heavy liquids / recycles into reactor, removes entrained coke dust.
 - Coke free hydrocarbon products leave scrubber overhead to product fractionator
- Heat for Reaction Supplied by Partially Combusting Coke in Burner
 - Hot coke particles flow in transfer line from burner to reactor
 - Cold coke particles flow from reactor to burner

FLUID COKING Unit

- Located in California
- Started up in 1969
- Currently 28 KB/SD
- Burner in Foreground
- Scrubber Above Reactor

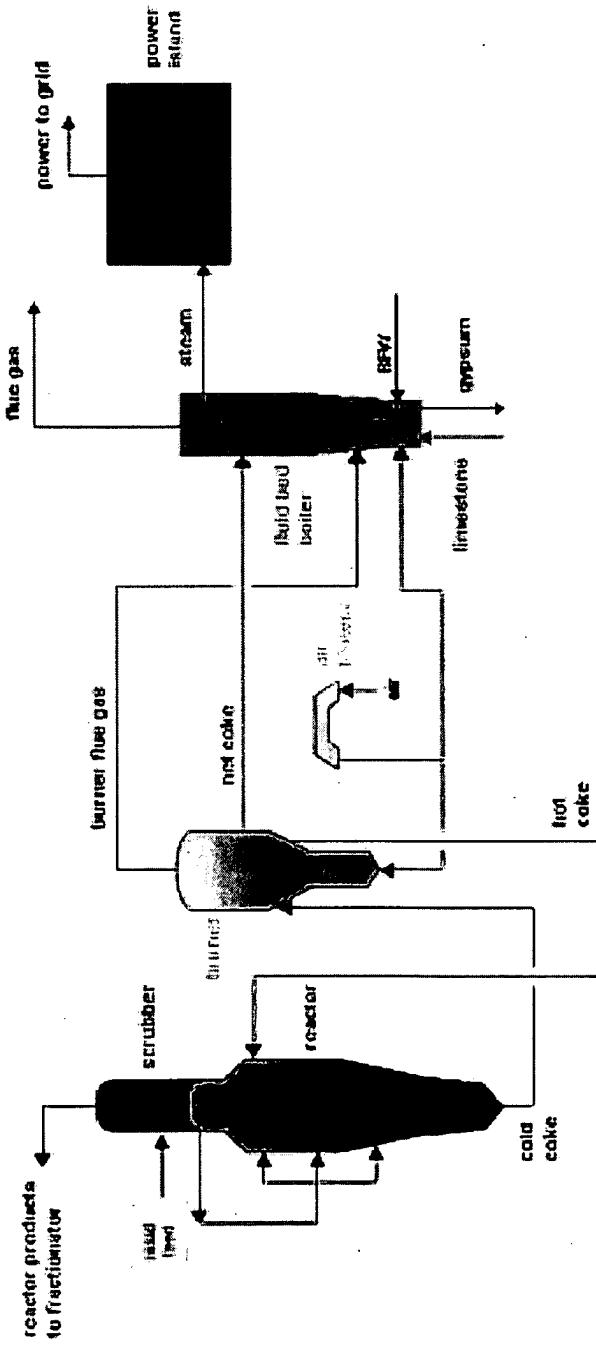


FLUID COKING: Coke Utilization

- About 20% of Coke Produced is Burned to Supply Process Heat
- Fluid Coke Typically Sold in the Solid Fuels Market
 - About half is sold as fuel to cement industry
 - Also a large % is burned in boilers and power plants
- Fluid Coke Used Directly in Commercial Fluid Bed Boilers to Produce Electricity/steam
 - Grinding not required due to small, uniform coke particle size
 - SO_x and NO_x emissions controlled with limestone & ammonia addition
 - Five sites in California generate ~100 MW
 - ExxonMobil a partner in ~ 60 MW co-generation project in Montana

FLUID COKING With Integrated Fluid Bed Boiler for Efficient Power Production

- FLK Coke Burned in Circulating Fluid Bed Boiler (CFBB) Produces High Pressure Steam to Drive Turbines to Produce Power
- FLK Burner Overhead and CFBB Flue Gas Streams Cleaned Together
- CFBB Can be Located either “On Site” or “Outside Refinery Fence”



FLUID COKING Commercial Experience

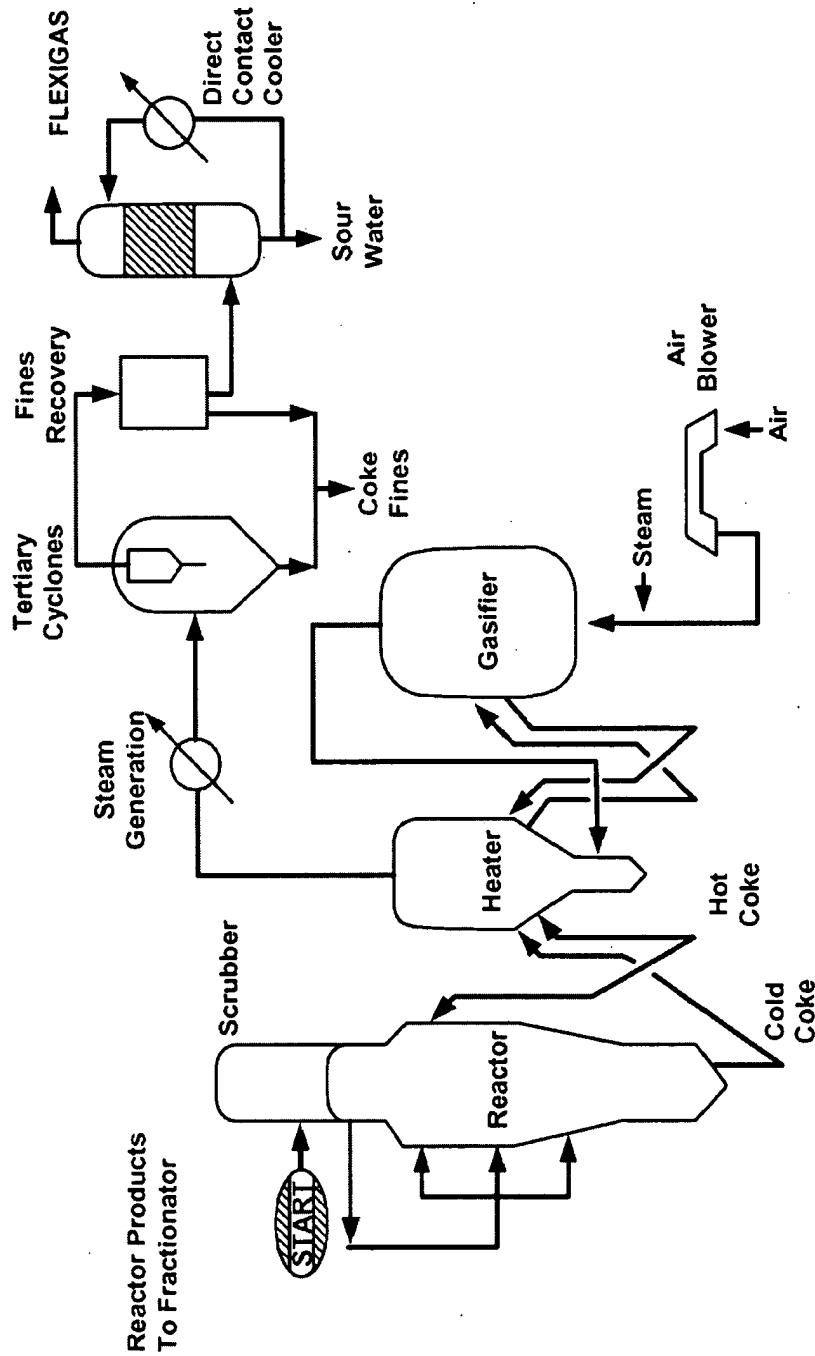
- First Commercial Application 50 Years Ago
- Over 330 Years of Cumulative Operating Experience; Significant Improvements in Capacity
- Currently 7 Units Process >365 kb/d; ExxonMobil Owns & Operates Two Units
- Largest Designed Unit Currently Under Construction in Canada

<u>Company</u>	<u>Location</u>	<u>Initial / Current Feed Rate, kb/d</u>
ExxonMobil	Montana	4 / 9
Tesoro	California	42 / 42
Premcor	Delaware	42 / 52
Imperial Oil	Canada	14 / 21
Valero	California	16 / 28
Syncrude	Canada	73 / 108
Syncrude	Canada	73 / 108
Syncrude	Canada	95*

* = under construction

FLEXICOKING Process

- Fluid Bed Coking With Integrated Air & Steam Gasification of Coke
- Produces Clean CO/ H₂ Rich Refinery Fuel Gas



1003-1104-01

Operating Principles of FLEXICOKING

- Reactor Design / Operation Similar to FLUID COKING
- Steam Gasification of Coke produces a Clean Fuel Gas (FLEXIGAS) from Lowest Value Stream in Refinery
- Process Heat Requirements are Supplied by Combustion of Coke with Air, Eliminating Need for External Fuel Supply
- Approximately 99% of the Products are Liquids and Gases
- Feed Metals Concentrated in Coke Fines Products
 - Markets: solid fuel, metallurgical applications, metals reclaiming
- Low Pressure Design Permits the Use of Standard Refractory Lined Carbon Steel Construction for Major Process Vessels

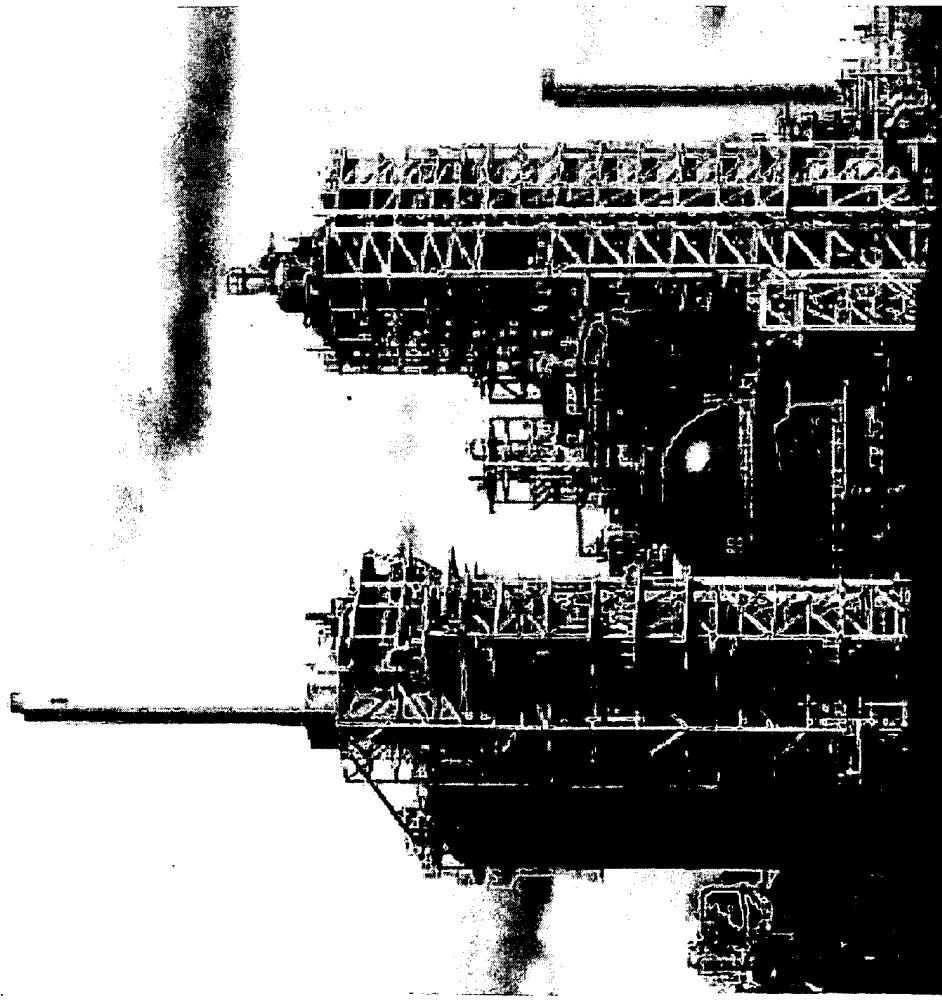
FLEXICOKING: FLEXIGAS Utilization



- **FLEXSORB® Gas Treating Technology Reduces Sulfur Content to Very Low Levels (< 10 vppm H₂S)**
- **FLEXIGAS is Rich in CO and H₂, Heating Value Reduced by Nitrogen Diluent in Combustion Air**
- **FLEXIGAS Burns Very Readily in a Number of Services in a Variety of Commercially Available Burners**
 - Process heaters (piping, naphtha reformers, hydrogen plant steam reformers, etc)
 - Utilities (steam generation, steam superheaters, gas turbine waste heat boilers)
 - Over-the-fence sales
- **Distribution System Costs are Low**

FLEXICOKING Unit

- Location: Rotterdam
- Started up in 1986
- Currently 40 KB/D
- Gasifier in Center (green)
- Coke Silos on Left
- Heater and Reactor / Scrubber on Right



Commercial FLEXICOKING UNITS

- FLEXICOKING First Commercialized Over 20 Years Ago
- Currently 5 Units Operating With a Total Capacity of >190 kB/D
- ExxonMobil Owns and Operates Two FLEXICOKING Units

<u>Company</u>	<u>Location</u>	Initial / Current Feed <u>Rate, kB/D</u>
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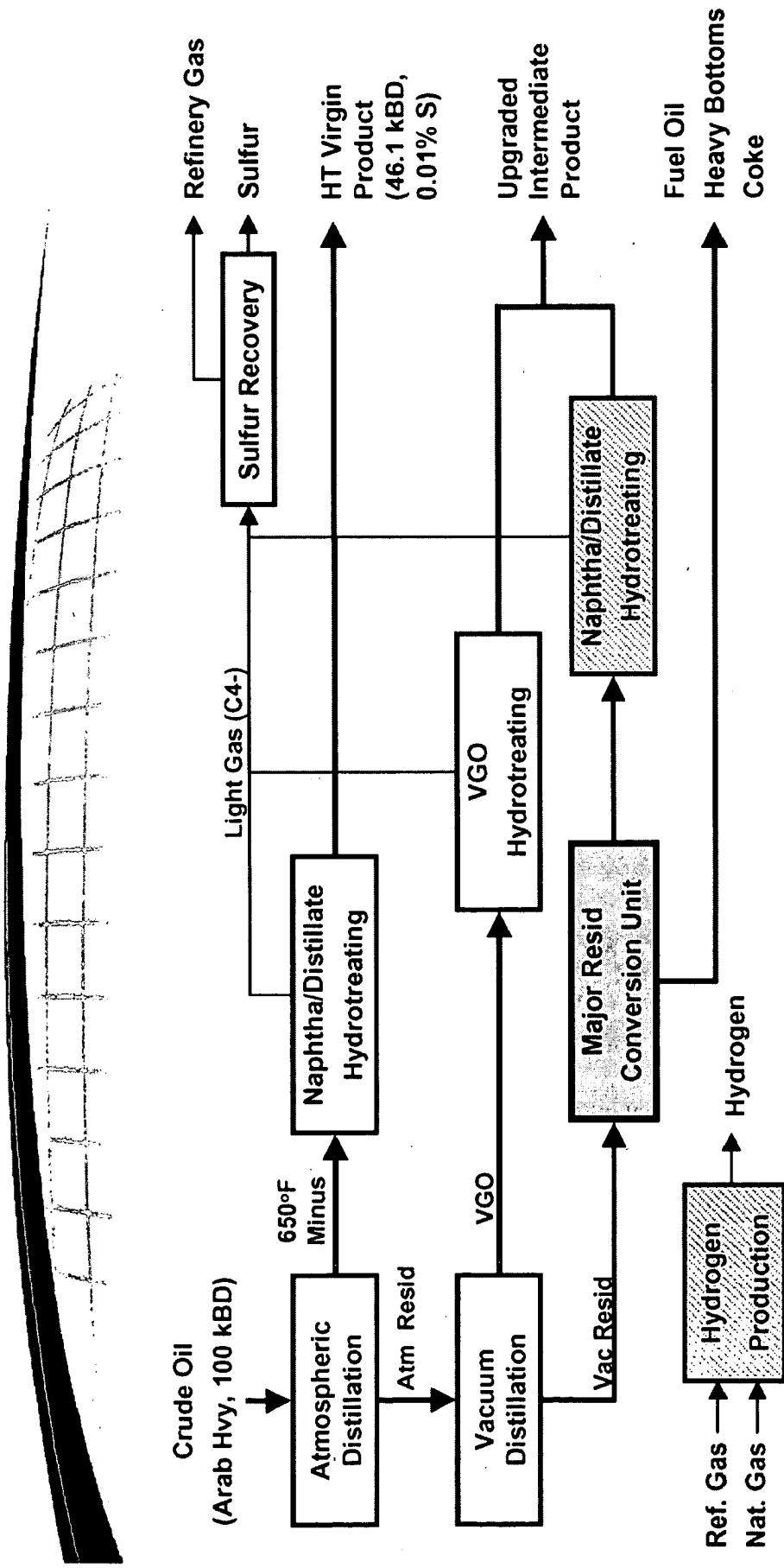
Showa-Shell	Japan	21 / 24
PdVSA	Venezuela	52 / 65
Shell	California	22 / 22
ExxonMobil	Netherlands	32 / 40
ExxonMobil	Texas	33 / 42

Economic Comparison of Hydroconversion and Thermal Conversion Technologies

- SFA Pacific Industry Study Provided Starting Point⁽¹⁾
 - Comparison Made on a Consistent Resid Conversion Project Basis
 - Constant Crude Rate to Refinery
 - Resid Conversion and Virgin Products Upgraded to Consistent Intermediate Product Quality
- EMRE Calculated Minimum “Gross Margin” Needed to Recover Total Cost for Each Resid Conversion Option
 - Gross Margin = Product Revenues - Crude Cost
 - Total Cost = Fixed (15% ROI) and Operating Costs
 - Compared Results for Hydroconversion and Coking Options
 - Examined Impact of Natural Gas Price on Results

1) SFA Pacific, Inc, “Upgrading Heavy Crude Oils and Residues to Transportation Fuels, Phase 7”, May 2003

Generalized Refinery Flowscheme - Conversion⁽¹⁾

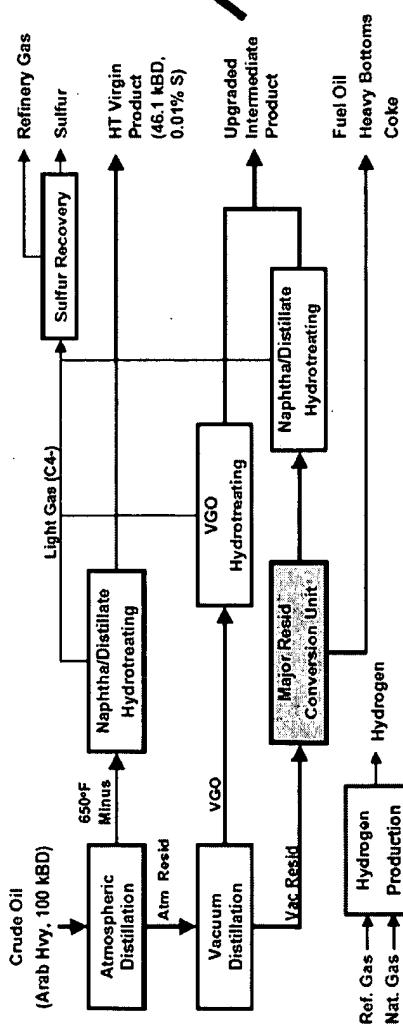


1) SFA Pacific, Inc, "Upgrading Heavy Crude Oils and Residues to Transportation Fuels, Phase 7", May 2003

Production of Upgraded Intermediate Products

- FLUID COKING, Delayed Coking, Hydroconversion Similar
- Hydroconversion + Coking or High Conversion Hydro. Produce More but Capital Cost and Bottoms Disposal are Issues

Resid Technology	Upg. Intermed. Prod.Rate(kBD)	Gravity (°API)	Sulfur (%)
Delayed Coking	46.3	32.8	0.08
FLUID COKING	47.0	31.9	0.08
FLEXICOKING	47.0	31.9	0.08
Hydrocracking @ 65% Conv.	48.2	32.2	0.08
Hydrocracking @ 65% Conv. with coking of bottoms	50.3	32.2	0.08
Hydrocracking @ 90% Conv.	52.6	33.0	0.07



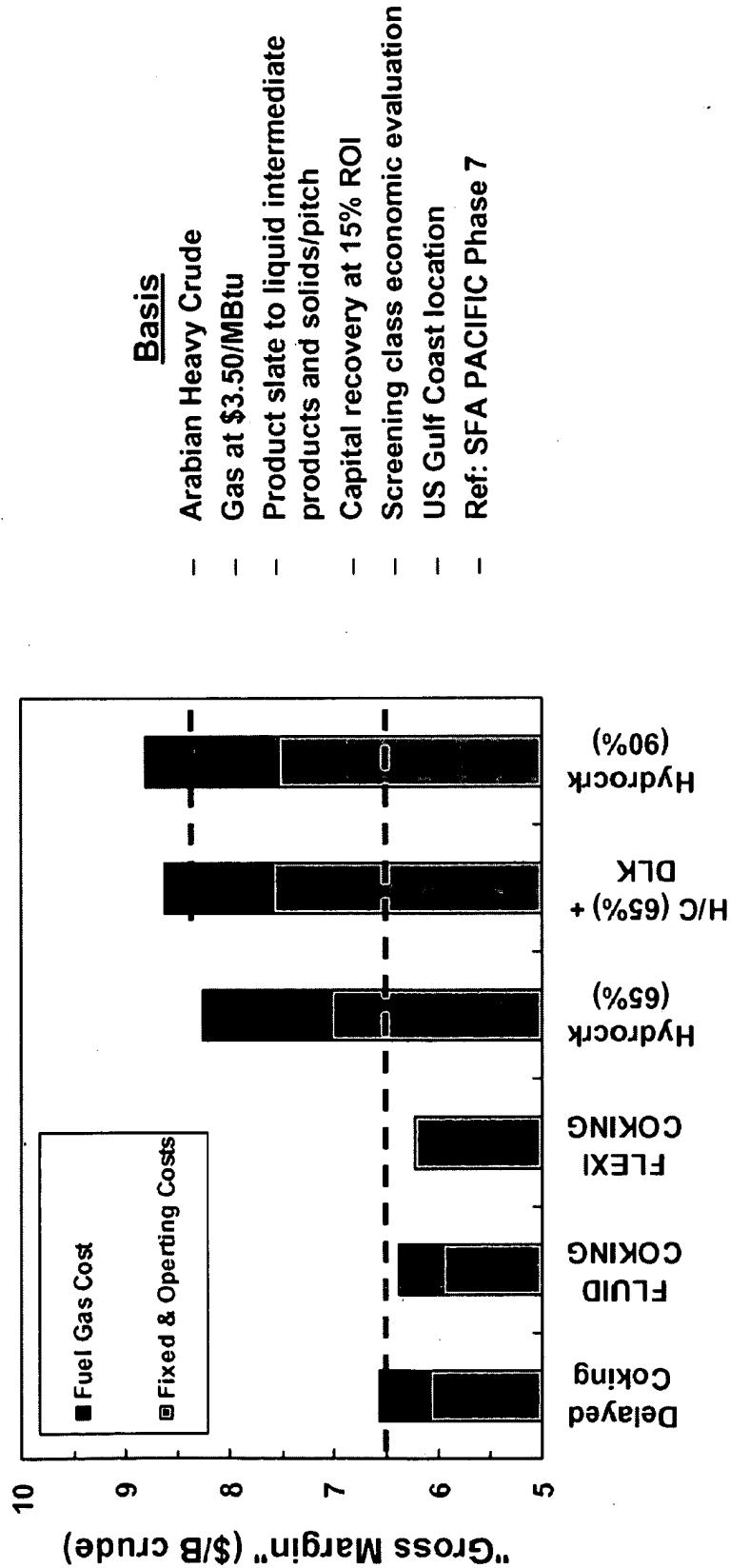
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Coking Has Economic Advantage vs Hydroconversion

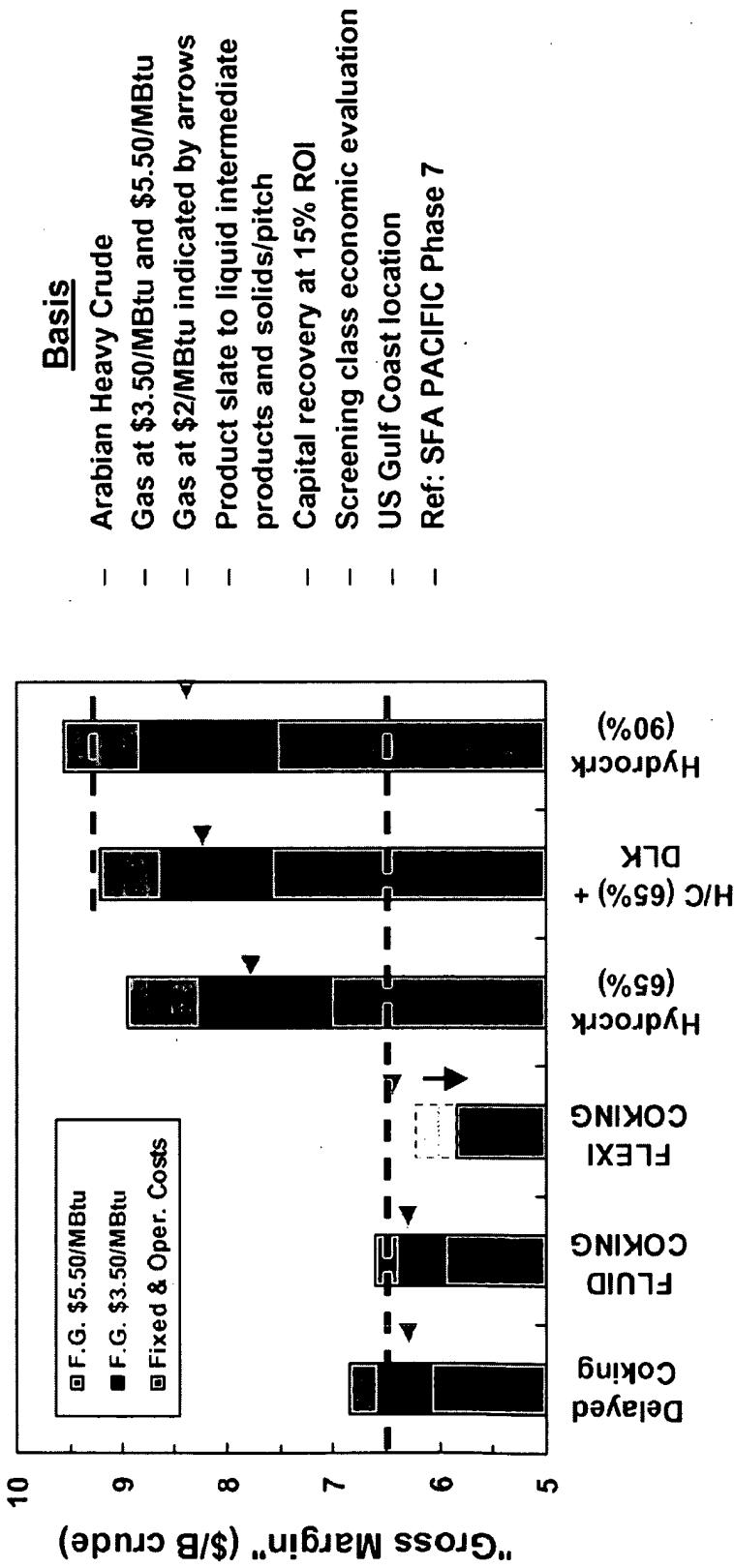


- Resid Conversion Attractive for “Gross Margin” > 7 \$/bbl
- Coking Has ~ 2\$/bbl Advantage over Hydroconversion Technologies
- Delayed Coking and FLUID COKING Require Similar Margin
- FLEXICOKING has an Advantage with Natural Gas at \$3.50/MMBtu



FLEXICOKING Has Significant Economic Advantage at High Gas Prices

- FLUID COKING Favored over Delayed Coking at Higher Gas Prices
- Coking Advantage vs Hydroconversion Increases with Gas Price (~3 \$/bbl)



Summary

- Growing Interest in Resid Conversion
- FLUID COKING is a Commercially Proven Technology and has Process Advantages over Delayed Coking
 - FLUID COKING can be efficiently integrated with a Fluid Bed Boiler for production of steam and electric power.
- FLEXICOKING is a Commercially Proven Technology That Produces Flexigas as Fuel Gas Substitute From Low Valued Coke
 - Flexigas can be burned in refinery or nearby plants.
- Economic Comparisons Show That Coking Generally Favored Over Hydroconversion
 - FLEXICOKING especially attractive at high natural gas prices